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NATIONAL SCIENCE AND TECHNOLOGY ISSUES

HEARING

BEFORE THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDRED FIRST CONGRESS

SECOND SESSION

ON

THE VIEWS OF THE DIRECTOR, NATIONAL SCIENCE FOUNDATION, ON NATIONAL SCIENCE AND TECHNOLOGY ISSUES

AUGUST 2, 1990

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NATIONAL SCIENCE AND TECHNOLOGY ISSUES

THURSDAY, AUGUST 2, 1990

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The Committee met, pursuant to notice, at 10:00 a.m. in room SR-253, Russell Senate Office Building, Hon. Ernest F. Hollings [Chairman of the Committee] presiding.

Staff members assigned to this hearing: Pat Windham, professional staff member and Fiona Branton, minority staff counsel.

OPENING STATEMENT BY THE CHAIRMAN

The CHAIRMAN. Good morning, and I welcome you to the hearing this morning to explore the views of Erich Bloch, the Director of the National Science Foundation, regarding the science and technology policy issues which now face our Nation. This hearing is both a tribute to the Director, who is now ending an exemplary 6-year term in this capacity, and an examination of some of the key science and technology issues of our time.

I believe that my colleagues will agree with me that Erich Bloch has served with great distinction as the National Science Foundation Director. He has been a forceful and successful advocate of greater Federal investments in research and science education, even in the face of administration policies to abolish Federal education programs and generally reduce, rather than increase, Federal research funding.

He also has become one of the most innovative science policy officials in the post-war era, determined to preserve the strengths and independence of the university research system while also nurturing closer ties between universities and the Nation's industry.

At a time when the country faced unprecedented challenges to its economic competitiveness, he worked to make the university research system more responsive to the technological needs of our country. He played a lead role in establishing the National Science Foundation's Engineering Research Centers, its Science and Technology Centers, and its Directorate for Computer and Information Science and Engineering.

He clearly has made an important contribution to our Nation's efforts to retain the world leadership position in science and technology. In light of his commitment and effort, I thought it was important to spend some time with him today exploring key science and technology issues. The Committee will hear the Director's views on the national needs now facing the country, the progress that has been made the past few years, and the work that remains

to be done. He is well qualified to speak on these issues both because of this NSF service and because of his many years as a senior executive with IBM.

This morning, we will explore his views on three major issues: the health of the university research system, the projected shortages of new scientists and engineers, and the continuing question of the technological competitiveness of U.S. industry.

Finally, I think it is appropriate, on an occasion such as this, to speak briefly of a person's character and the way his colleagues in Government view him. Erich Bloch came to this country from Europe after World War II after suffering family losses that most of us could not really comprehend. He came to this country as a stranger, made the United States his home, and went on to make major contributions to both industry and Government.

He holds the National Medal of Technology for his role in helping to create the modern computer, and everyone who knows him recognizes not only his directness but also his deep and thoughtful concern about the future of the country to which he has contributed so much. He is well respected by those who know him.

He once said that the United States now needs an event comparable to Sputnik to jar the Nation out of its complacency and awake it to the serious international economic competition it faces. He has called our attention to the great challenges we face, and knowing his tenacity and commitment, I am sure he will continue to speak out in the years ahead. Of course, we urge him to continue to do so.

Mr. Bloch, we commend you for your service to our Nation and the fact that yes, in 20 years you are the first Director to complete a full term, and the only individual I know around here amongst Gramm Rudman-Hollings that has doubled your budget rather than cut it, and really led the way and held on. So now I find the Bloch effect in the rhetoric and actions now in our colleagues. We are all talking about science, we are all talking about research, and I think it is in large measure that you have kept the fires burning for us.

So we welcome you, and we are delighted to hear from you at this time, when you can tell the Committee what you really think.

Senator Rockefeller do you wish to make a statement?

OPENING STATEMENT BY SENATOR ROCKEFELLER

Senator ROCKEFELLER. Mr. Chairman, thank you for holding this hearing today. I commend you on the subject matter and look forward to hearing Erich Bloch, whom I greatly respect, 'debrief' us on national science and technology issues. Erich is always candid and intelligent, and rarely seeks to sidestep controversial subjects, so I look forward to what should be a lively exchange.

Our nation has been extraordinarily fortunate over the past 6 years to have Erich Bloch at the helm of the National Science Foundation. When Erich took the reins at NSF, he was one of the first engineers to head up the agency. As an engineer, Erich intuitively understood that our Nation's R&D efforts needed to be more industrially oriented in order for the country to prosper. Erich Bloch—who has never been shy in his dealings with Congress—

tackled the difficult task of convincing us that research with industrial applications is the key to our nation's future.

It was no small accomplishment on Erich Bloch's part that the Reagan administration—which was not known for its budgetary generosity—repeatedly recommended the doubling of NSF's funding. In tight budgetary times, Erich was successful in convincing Congress, the Administration, and the Nation that scientific research pays in the long run.

Erich Bloch, in his straightforward manner, delivered a message to all of us. He made it clear that there is a connection between the research undertaken in the confines of our universities' laboratories and our nation's ability to compete in the next century.

On a personal note, I will always appreciate that Erich Bloch was the first NSF director to come to my state and talk to faculty members from West Virginia's two universities. Erich's visit encouraged faculty members, in a state that has ranked dead last in per capita federal R&D spending, to work with the NSF to build a strong research base in West Virginia.

I will miss Erich's leadership and I look forward to hearing what he has to say today.

The CHAIRMAN. Now we will hear from Mr. Bloch.

STATEMENT OF HON. ERICH BLOCH, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Mr. BLOCH. Thank you very much, Mr. Chairman, for your more than generous remarks, and secondly, for the opportunity to reflect with you on my tenure as Director of NSF, and also some of the issues that you mentioned a minute ago.

Before I get started, maybe I am permitted to introduce to you the new Deputy Director of the National Science Foundation, Dr. Fred Bernthal, who is here with us.

The CHAIRMAN. The Committee welcomes him. We have heard from him before, and he will be a wonderful substitute now at this hour, and we hope he can move right on in and take it over.

Mr. BLOCH. Well, Mr. Chairman, these past six years have been an opportune time to be the Director of the National Science Foundation. From the changes in the country, the world, and from the advances in science and engineering, and their changing role in the fortunes of the Nation have come the opportunities to reshape not only the programs, but the perspective of NSF and those associated with NSF, and indeed, of our grantees.

These were important opportunities to address, because the science and engineering infrastructure that is NSF's mandate is critical to the economic prosperity and the growth of the Nation.

I would like to spend the time this morning discussing first how and why that change has come about, then how NSF, as an agency, is adapting to this new environment. And in closing, I will sketch out some of the opportunities that lie ahead for both the agency and the Nation.

Let me talk about the environment first. One of the most important changes in affecting NSF has been the rise of the global economy. This global economy is a knowledge-based, skill-based economy. A nation's competitiveness is not so much determined anymore by

natural resources, access to low-cost labor, or other classical factors of production, but rather by the generation, access, and rapid deployment of new knowledge and technical insights, and new high-quality products and processes. And the availability of a technically-trained work force is an important consideration in that.

This new environment has brought with it increased economic competition as other nations have built up their capabilities in science, engineering, and technology. One result is that the U.S., in the dominant position in nearly all technologies at the end of World War II, is now challenged on many fronts. In this new environment, science and engineering basic research and education, the mission of NSF, is an investment in the future fortune of the Nation.

These changes also mean that NSF itself is at the very center of what is most important to our society today. This move of NSF's mission to center stage in the eyes of the public, the administration, and Congress, require changes within NSF itself.

How has NSF changed over the decade?

The most obvious, and I believe the most important, accomplishment during my tenure has been the revitalization of NSF's leadership in the area of mathematics, science, and engineering education, and human resource development. In 1982, NSF was almost entirely out of the education business. But that could not last. As I said before, the Nation today, more than ever, depends on a well-educated technical work force to compete in today's global economy.

Since 1982, NSF has put in place a framework of programs and strategy to address the Nation's math, science, and engineering education, and human resource needs. Our strategy addresses the whole process of education, from preschool to grade 12, to undergraduate and graduate study, and beyond.

NSF programs are basically designed to address the specific problems, opportunities, and needs at each critical stage of the educational process, and to strengthen the connecting links. The Nation's educational system is complex and decentralized. Our programs are designed to be catalysts and the projects we support are expected to be models for what can and should be done to improve the quality of the mathematics and science education provided throughout our system.

NSF has broadened its interest in education to include efforts to expand participation in science and engineering, and to recruit and retain more women and under-represented minorities in the educational pipeline. In the past, such programs were motivated by a desire for equity. Today, that motivation is joined by our concern over a shortage of human resources as demographics change.

In almost every field—education, research, facilities, and equipment—we have tried to leverage the federal budget through contributions from states and the private for-profit sector, and this is another way in which NSF has changed to meet contemporary demands. Partnerships are an effective way to maximize the Nation's total investment in science and engineering. And over the past decade, NSF has promoted such arrangements. The obvious examples are the Engineering Research Centers, the Science and Tech-

nology Centers, the Presidential Young Investigator Program, and many more.

These partnerships serve another important objective, that is, increasing the transfer of knowledge. Remaining competitive in world markets and creating solutions to many of the real problems facing society requires timely, complete, and effective communication of new knowledge, and greater cooperation among all those involved in research and technology.

In this regard, NSF's supercomputer centers are not only making a new tool accessible to a large community of researchers, they are also, through NSFNet, making a new communication method available that was not there before. And our efforts to improve and expand communication have not been limited to U.S. participants alone. No nation has a monopoly on knowledge. We must reach out and draw ideas and inspiration from foreign sources. NSF has sought to strengthen U.S. ties overseas through new bilateral research agreements with Japan and the USSR, and through greater cooperation on international research projects.

I have talked about changes in NSF's programs over the past several years. Let me now say something about what has stayed the same. And that is the basis mission of the Foundation. The mission of NSF is to support basic research and education in science and in engineering. It is a mission that ties NSF directly to the broader needs of the Nation. And in that respect, NSF programs should mirror those needs. That means supporting the full spectrum of research fields, newly emerging interdisciplinary science and technology fields, as well as the traditional disciplinary science.

It means supporting a range of research modes, including centers, groups, and international projects, and not only individual investigators. And it means supporting mathematics, science, and engineering at all levels, kindergarten through high school, and undergraduate as well as graduate education.

This interpretation may rankle those who view NSF's role as solely to advocate one approach to academic research in only a specific set of fields, or those who think there is not enough money to support everything. There is not, but NSF is not and can never be the captive of individual investigators or any other group for that matter, nor of science alone, nor of research alone.

NSF has broad responsibility for all the research modes, for engineering, and for education. And NSF must remain flexible and willing to respond quickly and effectively to new circumstances, whatever their source.

In this regard, I would like to thank Congress. It has allowed us the flexibility needed to respond to these changing conditions. The flexibility provided by our current five-year authorization is particularly valuable now, as the NSF budget increases, and recognition of NSF's contribution to economic competitiveness expands. This flexibility of NSF and its broad mission of supporting the infrastructure of science and engineering will, I hope, be called upon as new and different situations and requirements are faced by the Nation.

This, coupled with the knowledgeable and dedicated staff, are the assets that are at our disposal.

Now, looking towards the future, what opportunities lie ahead. In the next decades, I believe the central focus of U.S. policy is going to be the economic status of the country, and our ability to compete in international markets, and to improve the standard of living for all our citizens, and the condition of our environment. In this endeavor, the ability to create and use new knowledge will be paramount in achieving our national goals. That means research and education, and that means NSF.

Specifically, I see opportunities for NSF to make a positive difference in reaching the President's goal that America's students achieve international preeminence in math and science by the year 2000. I see opportunities at the pre-college level by working with State officials and local communities. NSF's new Statewide Systemic Initiative program serves this goal.

At the undergraduate level, there are more opportunities to make research experiences available to undergraduates, to enhance faculty competence, to improve courses and curricula for all undergraduates, not just those intending to pursue scientific careers, and to attract more women and minorities and also in that program we have industry participation.

At the graduate level, we can strengthen the ties between research and education through expanded fellowships and new initiative efforts, and to promote the expanded participation of everybody in this endeavor, the newly-created Directorate for Education and Human Resources will help us to take advantage of these opportunities.

The momentous changes in the Soviet Union and Eastern Europe present another set of opportunities. One likely result of this change is the opportunity to redress the imbalance in the Federal R&D funding to reflect the growing role of the civilian sector as a source of critical and primary technologies for the country.

There is an opportunity for the Government to provide partial support for research on generic technologies at the pre-competitive stage. In many areas the boundary lines between basic research and technologies are shrinking, if not overlapping completely. In these areas, generic technologies at this formative stage underlie entire industries and industrial sectors.

Investments are often too high and too risky for private companies because the technologies are evolving too quickly, or, as in some important industries, U.S. companies have lost the necessary technology base or cannot afford to compete with foreign competitors that are funded by their Governments in these endeavors.

The Federal Government must provide the kind of support often available to our foreign competitors in these critical technologies essential to entire industries and the industrial sectors. This will require that we rethink our technology strategy and our science policy similar to what we did after the war.

Finally, the improved international political climate opens new opportunities for communication and cooperation among nations, not only the developed nations but also between the developed and developing nations as well.

Many of our pressing national problems are global problems, like global warming and nuclear waste management. Their solutions will require global cooperation, and it is now possible. Day-to-day

communication between researchers across the globe is now possible via electronic networks, FAX computers and work stations. We are only seeing the beginning, but the potential is vast, yet this cooperation will only work if those nations who participate contribute their fair share and permit a true quid pro quo.

Lastly, we need to address the issue of priorities. We need to set priorities among our R&D efforts. We have too many costly projects, and we lack the wherewithal to fund them all. This prioritization needs to be accomplished both within Congress and the administration, as well as within the academic research community itself.

The years of plentiful Federal funding for basic research are past. While the Nation's resources have expanded, the research enterprise has expanded faster. Today, a list of all the promising basic research projects carries a price tag far above what the Federal Government is able or willing to pay. The research enterprise has outgrown the capacity to support it.

Both Congress and this administration, in conclusion, have demonstrated their strong commitment to NSF, its mission and its programs, and the President's science adviser, Allan Bromley, is providing vital leadership in coordinating Federal research and development activities.

We are embarking on a new era, one in which the prospects for peace and prosperity through economic growth have never been better. As the Federal Government seeks the growth incentives that will enable America to fulfill these prospects, let us remember the lessons of the recent past: strong and sustained public investment in research and education are two critical components of any successful strategy to promote economic growth.

Mr. Chairman, I have had the good fortune to serve NSF during a decade of change in the world, in the Nation, and in science and engineering. I have had the opportunity to lead NSF in new directions, pursuing its mission to strengthen research and education in math, science and engineering. In that task, I have had the help and support of this Committee, of Congress as a whole, and two administrations, and I am grateful for that support and I thank you.

Mr. Chairman, I would be happy to answer any questions you may have.

[The statement and questions and answers follow:]

ERICH BLOCH

DIRECTOR, NATIONAL SCIENCE FOUNDATION

TESTIMONY

U.S. SENATE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

August 2, 1990

Mr. Chairman, I appreciate the opportunity to testify before this Committee on the role of the National Science Foundation in today's changing environment.

These past six years have been an opportune time to be the Director of NSF. The changes in the country, the world, and in science and engineering, and their changing role in the fortunes of the Nation have provided the need and opportunity to reshape, not only the programs, but the perspective of NSF and those associated with it.

Perhaps the most important change has been the widespread recognition that NSF and its basic mandate, the science and engineering infrastructure, are critical to the economic prosperity and growth of the Nation. I would like to spend some time this morning discussing, first, how and why that change has come about; then, how NSF as an agency is adapting to this new environment; and in closing, I will sketch out some of the opportunities that lie ahead for both the agency and the Nation.

Changing Environment

One of the most important changes in effecting NSF been the rise of a global economy. Increasingly national markets are being supplanted by new international markets made possible by advanced transportation, communications, and information technologies.

This global economy is a knowledge-based, skill-based economy. A nation's competitiveness is not so much determined by natural resources, access to low-cost labor, and other classical factors of production, but rather by the generation, access, and rapid deployment of new knowledge and technical insights as new high quality products and processes. An available, technically trained workforce is the only way to accomplish this task.

This new environment has brought with it increased economic competition. There has been a rapid diffusion of technological capability and a rapid increase in the technically trained workforce worldwide. One result is that the U.S., in a dominant position in nearly all technologies at the end of World War II, is now challenged on many fronts.

In this new environment, the importance of science and engineering basic research and education have been elevated to a critical source of economic competitiveness and prosperity; and their funding is no longer simply a public expenditure, it is an investment in the future fortune of the Nation.

The solutions of virtually all the problems with which government is concerned:

- Health,
- Education,
- Environment,
- Energy,
- Urban development,
- International relationships,
- Space,
- Economic competitiveness, and
- Defense and national security

depend on creating new knowledge and transmitting that knowledge in usable form to all our citizens.

Even the definition of national security is changing. Today, our national security depends upon our ability to compete economically in this new global environment. Our national security also depends upon a strong and productive research and education enterprise and the technical laborforce that make that enterprise work.

What does this mean for NSF? It means that NSF is at the very center of what is most important to our society today. As such, it has received the recognition and commitment of two Presidents to double the NSF budget in five years.

The movement of NSF and its mission to center stage in eyes of the public, the Administration, and Congress required as closer association of NSF and its programs to the important problems and aspirations of the Nation.

Changes in NSF

How has this been accomplished? How has NSF changed over the decade?

Education and Human Resources

The most obvious, and I believe the most important, accomplishment during my tenure has been the revitalization of NSF's leadership in the area of math, science and engineering education and human resource development. In 1982, NSF was almost entirely out of the education business. But that could not last. Not only does NSF's mission statement give it a major role in the math, science and engineering education, the Nation depends upon a well-educated technical workforce to compete in today's global economy.

NSF has broadened its interest in education to include efforts to expand participation in science and engineering and recruit and retain more women and underrepresented minorities in the educational pipeline. In the past, programs to increase participation were motivated by a desire for equity. Today, that motivation is joined by national self-interest. There simply are not going to be enough white men in the appropriate age groups to meet the Nation's demand for scientists and engineers in the future.

Since 1982, NSF has put in place a framework of programs and strategy to address the Nation's math, science, and engineering education and human resource needs. Our strategy is based on an understanding that the educational process is a series of interdependent and interconnected stages, with links from preschool to Grade 12, to undergraduate and graduate study and beyond. NSF programs are designed to address the specific problems, opportunities, and needs at each critical stage, and to strengthen the connecting links.

Our strategy is also based on the realization that the Nation's educational system is complex and decentralized, with primary responsibilities located at the state and local levels. Our programs are designed to be catalysts and the projects we support are expected to be models for what can and should be done to improve the quality of the math and science education provided throughout our education system.

Given our limited resources -- NSF comprises only a small part of the federal funding for education -- NSF programs are also designed to leverage additional public and private resources available at the national, state, and local levels. By involving state and local governments, parents, school boards, businesses, and communities in NSF programs, wherever appropriate, we seek to enhance their impact and effectiveness. NSF projects serve as

models and our programs are designed to encourage innovation and systemic reform.

Partnerships and Leveraging

This increased emphasis on partnerships and leveraging our resources is another way in which NSF has changed to meet contemporary demands.

The years of plentiful Federal funding for basic research are past. While the Nation's resources have expanded, the research enterprise has expanded faster. Today, a list of all the promising basic research projects carries a price tag far above what the Federal government is able and willing to pay. The best ideas in may face diminishing capabilities for support of them.

Cooperative arrangements -- between relevant Federal agencies and state governments, and other non-profit, academic, and industrial research sponsors -- are an effective way to maximize the Nation's total investment in science and engineering. And over the past decade, NSF has promoted such arrangements. The obvious examples are the Engineering Research Centers and the Science and Technology Centers, but there are many other examples as well:

- College Science Instrumentation Program -- With substantial cost sharing by awardee institutions, states, equipment manufacturers, and other elements of the private sector, this program stimulates laboratory instruction improvements at our Nation's colleges and universities.
- Instructional Materials Development -- In the area of K-12 math and science education, this program supports development of new materials and strategies of instruction with an emphasis on dissemination and implementation through cooperation with publishers and school systems.
- Industry/University Cooperative Research Centers -- These campus-based research centers are co-sponsored by industry in fields with industrial relevance.
- Presidential Young Investigator Awards -- Outstanding young science and engineering faculty can receive up to $100,000 for research with matching funds from industry.
- Small Business Innovation Research -- A three-phase program that offers incentives for research in small firms, from initiation to commercialization.

These cooperative endeavors serve another important objective, that is, increasing the transfer of knowledge. Broad distribution and discussion of research results increases a nation's capacity to absorb and use new knowledge. It is a mistake to separate science from engineering, research from technology.

Innovation is an interactive, iterative process. Rarely does a fundamental research result find a rapid and straightforward application. It is the flow of ideas and information back and forth between originators and users that creates new products and technologies.

In another vein, society's problems will always be an important source of inspiration for scientific research. Cancer, heart disease, AIDS, earthquake prediction and hazard mitigation, waste management -- these are all real problems in need of clinical or technical solutions. More cooperation and better integration of basic research with other activities in society will speed our finding of those solutions.

The separation that has occurred in the U.S. between industry and academic research is not without cost to the Nation and our economic standing. Remaining competitive in world markets and creating solutions to many of the real problems facing society requires timely, complete, and effective communication of new knowledge and results to those who can use them. It requires greater cooperation among all those involved in research and technology.

Cooperation, Communication and Computer Networks

Another important change at NSF in the past decade has been the growth in the area of computer science and networking. NSF's supercomputer centers are making a fast new data processing system accessible to a large community of researchers. That was their primary purpose. But, at the same time, work at these centers has given us new insights into how to use supercomputers; out of that has come such things as visualization. Through these centers and NSFNet, we have strengthened our research infrastructure by making both a new tool and a new communication path available.

Moreover, our efforts to improve and expand communication have not been limited to U.S. participants alone. No nation has a monopoly on knowledge. Now more than ever, researchers--both in academia and industry--must reach out and draw ideas and inspiration from foreign sources. Yet compared to other scientists and engineers around the world -- including those in Europe and the Pacific Rim -- Americans have been slow to appreciate the value of foreign endeavors. We have been slow to seek research opportunities abroad, relying more on others to establish and promote collaborations.

The U.S. can no longer afford this approach. And NSF has sought to strengthen U.S. ties overseas through new bilateral research agreements with Japan and the USSR, and through greater cooperation on international research projects.

The NSF Mission

I've talked about changes in NSF's programs over the past several years. Let me now say something about what has stayed the same.

The primary mission of NSF is to support basic research and education in science and engineering. It is a mission that, today more than ever, ties NSF directly to the broader needs of the Nation. And in that respect, NSF programs should mirror those needs. That means supporting the full spectrum of research fields -- including computer science, engineering, and newly-emerging interdisciplinary science and technology fields as well as the traditional disciplinary science fields. That means supporting a range of research modes -- including centers, groups, and international projects as well as individual investigators. That means supporting math, science and engineering education at all levels -- kindergarten through high school; undergraduate as well as graduate and postdoctoral studies.

This interpretation may rankle those who view NSF's role as solely to advocate one approach to academic research in only a specific set of fields. But NSF is not the captive of individual investigators; NSF supports groups and centers as well. NSF does not focus solely on science; NSF supports engineering as well. NSF supports more than research; we are increasingly responsible for math, science, and engineering education.

NSF has broad responsibilities to promote the progress of science and engineering research and education. To fulfill its responsibility, NSF must remain flexible and willing to respond quickly and effectively to new circumstances, whatever their source.

Responding to Change

I believe that over the past decade NSF has exhibited that kind of flexibility and responsiveness to the changing circumstances I've described already. NSF has taken the initiative

- in improving math, science and engineering education at all levels, from kindergarten through high school, college, graduate school, and beyond;
- in broadening the participation among women, underrepresented minorities, and the disabled in science and engineering;
- in encouraging greater cooperation among the various sectors interested and involved in research and technology, and
- in promoting institutional changes, like centers, on campuses; and
- in creating a new framework for international collaborations between U.S. researchers and their counterparts in other developed and developing nations.

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In developing new programs to meet these needs, NSF has been guided by the full participation of the research and education community through their work as project reviewers, program and project advisors, and rotating staff. And the National Science Board has offered valuable direction to our efforts also. Through continual internal and external review, NSF has been able to respond quickly and, I believe, effectively to new opportunities and objectives as they arise.

And in this regard, I'd like to thank Congress also. Congress has continue to provide us the flexibility needed to respond to these changing conditions. The flexible framework provided by our current five-year authorization is particularly valuable now as the NSF budget increases and recognition of NSF's contribution to economic competitiveness expands.

Let me add that I expect the Foundation will continue to be looked to as an agency capable of taking on new and additional responsibilities to address important national problems. Its success has already made NSF the subject of a number of proposals to take on new programs and expanded functions. NSF has and will continue to accept these challenges and view them as important opportunities for the scientific and engineering community and the Nation.

I firmly believe the Foundation is a special, very unique federal agency. A large part of our success is that we are blessed with an extremely capable and highly dedicated staff. To maximize the talents of the people who make up the organization, the organization must be allowed to continue to demonstrate its creativity and innovation.

Opportunities Ahead

Now, looking toward the future, what opportunities lie ahead?

In the next decades, I believe the central focus of the U.S. policy is going to be on economics, on our ability to compete on international markets, and to sustain and improve the standard of living for all our citizens. In this endeavor, the ability to create and use new knowledge will be paramount in achieving our national goals. That means research and education; that means NSF.

Education and Human Resources

Specifically, I see more opportunities for NSF to make a positive difference in the areas of math, science, and engineering education. The President's pledge that American students will achieve international preeminence in math and science by the year 2000 is a mandate to NSF.

- I see opportunities at the precollege level to achieve the kind of systemic, comprehensive changes that are needed to improve the teaching and understanding of science and mathematics in all grades. This will be done increasingly by working with state officials and local communities and by building on the many teacher training and curriculum development projects NSF already supports. NSF's new Statewide Initiative program serves this goal.

- At the undergraduate level, there are more opportunities to make research experiences available to undergraduates, to enhance faculty competence, to improve courses and curricula for all undergraduates -- not just those intending to pursue scientific careers -- and to aid many different types of institutions in acquiring research instrumentation needed to improve undergraduate laboratory instruction.

- At the graduate level, we can build on our well-known excellence to strengthen the tie between research and education through expanded fellowships and new traineeship efforts, to strengthen the academic research infrastructure, and to promote the expanded participation of women and underrepresented minorities on faculties and in research.

The structure and enhanced responsibilities of the new Directorate for Education and Human Resources will help us to take advantage of these opportunities. It will help us to help the Nation meet the education goals set by the President and endorsed by the National Governors Association.

Federal R&D Support

The momentous changes in the Soviet Union and Eastern Europe present another set of opportunities. The world is emerging from the Cold War -- from a period in which the major focus of the U.S. was on military and political matters. One likely result of this change is the opportunity to redress the imbalance in Federal R&D funding to reflect the growing role of the civilian sector as a source of critical commercial technologies.

There is an opportunity for the government to provide partial support for research on generic technologies at the precompetitive stage. In many areas, the boundary lines between basic research

and technology are shrinking, if not overlapping completely. In these areas, generic technologies at this formative stage underlie entire industries and industrial sectors. Investments are often too high and too risky for private companies because the technologies are evolving too quickly or, as in some important industries, U.S. companies have lost the necessary technology base or cannot afford to compete with foreign competitors funded by their governments.

The Federal government can provide the kind of research support often available to our foreign competitors in those critical technologies essential to entire industries and industrial sectors.

International Cooperation

Finally, the improved international political climate opens new opportunities for communication and cooperation among nations, not only the developed nations but also between the developed and developing nations as well.

Many of our pressing national problems are global problems, like global warming and nuclear waste management. Their solutions will require global cooperation. And it's now possible. Day-to-day communication between researchers across the globe is now possible via electronic networks, fax, computers, and workstations. We're only beginning to see the effect, but the potential is vast.

Yet while the rapid diffusion of new knowledge can enrich all nations that promote this new mode of communication, it will only work if those who participate contribute their fair share and permit a true quid pro quo. Access to the newest research is a source of competitive advantage, especially when the prospects of early commercialization are real. There will be political pressure to limit access to research information. We can acknowledge these pressures without succumbing to them.

R&D Priorities

And lastly, we need to address the issue of priorities. We need to set priorities among our R&D efforts. We have too many costly projects and we lack the resources to fund them all. This prioritization needs to be accomplished both within Congress and the Administration.

Conclusion

Both Congress and this Administration have demonstrated their strong commitment to NSF, its mission and its programs. And the President's Science Advisor, Allan Bromley is providing vital leadership in coordinating Federal research and development activities.

The voices of the science and technology communities have achieved new authority throughout the policy-making process here in Washington, not only within the Administration, but in Congress as well. A wealth of opportunities await the next NSF Director.

We are embarking on a new era -- one in which the prospects for peace and world prosperity through economic growth have never been better. As the Federal government seeks the growth incentives that will enable America to fulfill these prospects, let us remember the lessons of the recent past. Strong and sustained public investments in basic research and science and mathematics education are two critical components of any successful strategy to promote economic growth. Our Nation needs to focus on those activities of government that can lead to future economic growth--and to establish them as national priorities.

I have had the good fortune to serve NSF during a decade of great change -- in the world, in the nation, and in science and engineering. I have had the opportunity to lead NSF in new directions pursuing its mission to strengthen research and education in math, science, and engineering. In that task, I have had the help and support of this committee and Congress and two Administrations. I am grateful and I thank you.

Mr. Chairman, I will be happy to answer any questions you may have now.

(B)

QUESTIONS FOR THE RECORD
FROM SENATOR STEVENS

SENATOR STEVENS: The President's FY91 budget request includes $16 million for Arctic research and $175 million for Antarctic research, an increase of $25 million. Most of the money for Antarctic research goes into logistics. It seems logical to focus more attention on the Arctic, where logistical obstacles are fewer.

Focusing more attention on the Arctic also makes sense because at least a portion of the United States is located above the Arctic Circle. There are a number of important domestic policy issues that could be resolved more intelligently if adequate research could be done on problems related to offshore oil and gas production in the Arctic Ocean, the impact of seismic activity on whales and other marine mammals, ice impacts on bottomfish and salmon migration and production, etc.

Why doesn't NSF allocate more of its resources to Arctic research, which could have more direct benefit for the United States, particularly since less money would have to be devoted to overcoming logistical obstacles?

MR. BLOCH: NSF recognizes the importance of arctic research and has been advocating increased polar research for a number of years. During the period FY 1987-90 the budget for the Arctic Research Program within the Division of Polar Programs has risen 54% while the Antarctic Program has grown by 35%. In the FY 1991 request the Arctic Research Program grows at about three times the rate of the Antarctic Program.

Including support provided through disciplinary research programs as well as the Arctic Research Program, total NSF funding for Arctic research in FY 1991 will exceed $31 million; funding for the Antarctic Research Program in FY 1991 will total $19 million. However, total federal funding for research in the Arctic is estimated at $125 million in FY 1991, roughly six times the amount anticipated for research in the Antarctic.

The United States Antarctic Program (USAP) concentrates on research unique to Antarctica, a polar continent surrounded by oceans, which is quite unlike the Arctic in many ways. Research topics have included South Pole astrophysics, the southern ozone hole and other studies related to climate change.

The program exists in part because Antarctica is a continent on which conflicting territorial claims of other Nations are held in abeyance under the Antarctic Treaty. Science is a key element of the U.S. presence that underpins our position in the Antarctic Treaty System.

Part of the antarctic increase results from a special initiative

for safety and environmental concerns. It is important to make progress on these issues because of their merits.

SENATOR STEVENS: Would NSF object to reallocating a small portion of the Antarctic research funds, say $5 million, into Arctic research?

MR. BLOCH: NSF's request for Arctic research is appropriate and is part of a balanced approach to research in the polar regions.

Much of the increase for the U.S. Antarctic Program (USAP) supports the Safety, Environment, and Health Initiative. A decrease in funds from the request would hinder the ability of USAP to carry out this important initiative.

SENATOR STEVENS: In its April 1990 Long-Range Science Plan, the Division of Polar Programs indicates that

> a long list of pending and planned Arctic research programs, including the high-latitude oceanic and atmospheric processes require an icebreaking vessel. The Committee's assessment of scientific needs projected requirements for some 200 to 300 days of ship time per year. The Advisory Committee supports the efforts of Arctic research community to obtain an appropriate research vessel, and encourages the NSF to favorably consider their proposal for acquisition of such a vessel. Acquisition of an Arctic research vessel is included in the NSF's Ocean Sciences Division's long-range plan.

The long-range plan calls for "acquisition of an ice-capable ship to replace the R/V ALPHA HELIX by 1994." Last year, I considered requesting planning money for the ship, but NSF advised me it would include planning funds in this year's budget. But it didn't. Instead, NSF requested acquisition funds for an ice-worthy ship for ANTARCTIC research.

In order to have an Arctic research vessel on line by 1994, planning must begin now. Why didn't NSF request planning money for acquisition of an Arctic research vessel in its FY91 budget request?

MR. BLOCH: The most recent long-range plan for NSF's Geosciences Activity calls for the acquisition of an ice-capable research ship to support research in the western Arctic by 1995. The standard design cycle for a new research ship begins with a Concept Design phase, continues with a Preliminary Design phase, and ends with the Contract Design phase leading to construction.

We have already started the planning process in FY 1990 with an award to Vera D. Alexander, Robert W. Elsner and Thomas C. Royer

of the University of Alaska Fairbanks for a "Concept Design for an Intermediate Ice-Capable Research Vessel" (OCE 90-13230). This planning phase will be completed in 1991 and lead to the Preliminary Design phase in early FY 1992.

The required funds for the Preliminary Design are available within our ongoing base programs and, therefore, are included within the FY 1991 request, though not specifically called out.

SENATOR STEVENS: I have requested $2.5 million in the FY91 HUD and Related Agencies bill to begin the planning process. Will NSF support my request?

MR. BLOCH: NSF has already begun the planning process for an Arctic research vessel with FY 1990 funds, and expects to provide all required support in FY 1991 from ongoing programs. Additional support for the planning process is not necessary at this time.

SENATOR STEVENS: Since plans are going forward for acquisition of an Antarctic research vessel, would NSF object to stationing that ship in the Arctic during a portion of the year so that researchers on both poles can conduct vital research?

MR. BLOCH: The research community needs ice-capable research vessels both in the Arctic and in the southern oceans around Antarctica. It is not feasible for one vessel to meet requirements in both regions. Transit times between the two polar regions would increase costs and decrease the total availability of the ship for research. Having a new research vessel for the many northern science needs would seem a much better solution.

The planned approach to meet Arctic research requirements until the Arctic polar research vessel is available in 1995 includes cooperative field operations with other countries, use of U.S. Coast Guard icebreakers as appropriate, and project-specific charters of commercial ice-capable vessels.

The CHAIRMAN. Well, we are grateful, and we thank you specifically, Mr. Bloch.

On the prioritizing of needs, who better to give us a priority list than you? Mine would be political. The administration's would be political. Yours would be scientific, and that would really have more weight, and we should perhaps respond and follow your list.

What is your list? The National Science Foundation has been working in this field and watching the developments, and you have given us a broad statement of the changes that have come about over the last decade, internationally as well as nationally. What is your list? What is your priority?

Mr. BLOCH. My priority list is generic in nature, as it has to be, because you cannot be very specific and single out some projects over others. They are all thought through. They are all important.

But I think the most important thing is to lay the foundation in place and make sure that that foundation is kept up to date, and that means the support of people, and that means education. That means basic research in universities where education and research intersect, essentially, and make sure that the wherewithal is there to attract new people into this process of research and of science,

because unless we renew it we are not going to be up to date in 10, 20 or 30 years from now.

So I have always felt, and the Foundation represents it, but not solely, that the support of people, of basic research, of education, should come ahead of some of the big projects that are equally important, no doubt about it—like the SSC or like the human genome project, or like the Space Station.

You could mention many more, but I think in a fiscally constrained environment, one has to really protect the base first—the people and the equipment that are required for that research—before one goes after these big projects. Not that they are unimportant. Quite the contrary, they are important.

The CHAIRMAN. Very good, and I want to yield to our colleagues here. We appreciate the attendance this morning.

But when you say that U.S. companies cannot afford to compete with the foreign competitors funded by their Governments, and that the Federal Government can provide the kind of research support to us and to our companies, how? In other words, you are right into this so-called industrial policy yin yang that we hear about.

No one contemplates an industrial policy, the picking of winners and losers and that kind of nonsense, that gets into political jargon. But from the science and engineering standpoint, and your experience over the years how would you suggest we do it?

Mr. BLOCH. Well, what I made reference to primarily was generic technology development, and generic technology development does not get into the area that you mentioned. I do not want to repeat the "no" words that you mentioned before myself, but it does not get into that area at all. It is far removed from the marketplace. It is closer to the marketplace, no doubt about it, than basic research and the sciences, but it is equally important.

I think one has to think about what technologies, what generic technologies are important for the future of the country, and it cannot be 30, it cannot be 40. It can be three, or four, or five, or six that are so profound and so important that we cannot afford to give up the base in the country for these technologies.

The CHAIRMAN. What three?

Mr. BLOCH. Well, that is a good issue, but I will give you again some very generic ones. Certainly some of the materials areas, because the materials research area, I think we are underestimating what new materials will do for us and how they will take over many functions that today are being done otherwise.

I think the whole area of biotechnology is certainly one of these broad areas. It is not a narrow area. It is a very broad area, and so there are two examples. I think the whole area of manufacturing integration is one of those generic areas that we have been neglecting and that our companies have been neglecting, and so there are three examples, and I probably can find three more, but I do not think I can find 10 or 15 more that are close to these in their importance.

What I think has to happen in the near future, if we do not want to lose the base in these technologies, is that when industry and Government get together and put in place laboratories or consortia, and there are some examples of that, by the way, there is not just

one particular approach. There are many approaches that provide this technology for all of our companies and for the country as a whole, just like after the World War.

Vannevar Bush had the idea and sold it to Congress and to the administration that basic research would be important. I think we are at a turning point where basic research is as important as it always has been, but in addition to that, generic technologies are becoming more and more important. The cost of doing this kind of work has gone up tremendously. Many of our companies have lost their base.

See what goes on in Europe today, and what goes on in Japan. The Governments very actively—and I do not propose that we are doing it in exactly the same way, but there the Governments, in a very active kind of a way, are putting these consortia together to address exactly these issues, and we have to find an American approach to the same problem.

The CHAIRMAN. Senator Danforth.

Senator DANFORTH. Mr. Bloch, thank you very much for your testimony and for your service.

And, Mr. Chairman, thank you for convening this very important meeting of the Committee.

Mr. Bloch, one thing that I have heard from the university community, including some of our best endowed universities, is that there seems to be an insatiable need for large capital investment, buildings, laboratories, and very expensive equipment. And the view that I have heard is that this is going to continue to be a very significant challenge, even for those universities which are generally viewed as being in excellent economic shape.

Do you agree with that?

Mr. BLOCH. Well, I agree that there is an insatiable need for that. Letme separate it, because you mentioned two things. One is equipment and the other one is buildings, and I really would like to separate the two. In the equipment area, there is no doubt about it, that with the rapid changes that are occurring in science and in engineering, and in instrumentation, the equipment issues will be with us, I will say, forever.

We have tried to address it in the National Science Foundation by increasing our equipment expenditures over the last few years to the point where, today, they are about 13 percent of our total budget. And if you had looked 10 or 15 years ago, it probably would have been more like 8 or 9 percent. It is not enough, 13 percent. It should be probably more than the 25 to 26 percent level, but it helps.

So the equipment issue is very much with us. I hear the same thing about new buildings. On the other hand, I must say that, over the last three years, we have done, every year, or every 18 months I think, a survey of new buildings and renovations for buildings going up, and there is some work going on. A lot of it is sponsored by the states. Some of it is sponsored through private giving and so forth.

We have a program that we have put in place at the urging of Congress, last year and this year, to address that particular problem. It is a relatively small program. It is $20 million per year, which does not go very far. But of the two items that you men-

tioned, I would put it in the priority order of equipment first and then buildings.

Senator DANFORTH. That is pretty expensive equipment, is it not?

Mr. BLOCH. Yes, and getting more expensive.

Senator DANFORTH. Mr. Chairman, the only other thing I would say is in the nature of a comment, rather than a question. I think that you, Mr. Chairman, have really put the question well, and I think that Mr. Bloch also really said the same thing, it has to do with priorities and the need to establish priorities. I do not know anything about science. I have absolutely no talent or knowledge in the area. But I do believe that it is very important to the future of this country.

And I think that that is generally recognized by people in Washington. I also think that it is clear that the policy of the Federal Government, for better or worse, affects science in this country. We can do things that help science, and we can do things that hurt science.

I think one of the frustrations, particularly of this 101st Congress, is the sense that some of our members, and I am one of them, seem to be spending a lot of time doing nothing. In areas where there is a clear recognition of a need or of a goal, we seem to be stymied. We pass legislation that is not going to become law. We are involved in a lot of battling for partisan advantage in major areas.

But it seems to me that if we recognize, a lot of us anyhow in the Congress, that science is going to be a major need and the major challenge for a healthy and growing country, then perhaps, at least in this one area, there could be some way in which we in Congress, on a sustained basis, could commit ourselves to making things better, rather than making things worse. And I am not sure exactly how to do it.

I know that Senator Boren has been instrumental in putting together some university presidents with various members of the Senate Finance Committee, to talk about the relationship between tax policy and the university community, and particularly, science. Tax policy is clearly related to the health of our universities. And yet, oftentimes we make tax policy without particular concern for the impact on our universities.

Spending priorities, so often, it seems to me, questions on how we spend science dollars here in Washington boil down to a question of what state is going to be advantaged. Who is going to end up with the supercollider. Or who is going to be able to earmark what funds in what appropriations bill.

Now I was not born yesterday. I have been beating my head against that wall, and maybe it is not very useful to do it. Maybe we can never resolve that. But it seems to me that one thing that we might consider, we being the members of the Commerce Committee, and particularly the Chairman of the full Committee and the Chairman of the Subcommittee on Science, Senator Gore, is whether it would be possible not just sporadically, you know, meeting with Mr. Bloch, but on a systematic, sustained basis to be participants in being a constant voice for science. And perhaps likened to NOPS, the National Ocean Policy Study, involving members of various committees of Congress. Perhaps there could be some way,

on an inter-committee basis, to bring together interested senators to try to find out where we do agree. We are not going to agree on everything. I mean some senator may be pushing some special project. But I think that Mr. Bloch has pointed us in the right direction when he pointed us to generic issues, rather than project-specific issues.

Maybe we are less equipped to deal with—or maybe we should not be dealing so much with whose state gets what specific grant than the more general problems. And maybe there are ways that we can put together a concerted effort to deal with that.

So I guess my question is less to Mr. Bloch than to anybody else who is interested, and that is, where do we go from here? Where do we go from this meeting, other than to lunch? What happens next?

I would think that if we wanted to, and I am really thinking out loud, but if we wanted to, we, or some of us on the Committee, together with members of the Finance Committee, together with maybe the Intelligence Committee, would be interested in this. I am sure the Energy Committee is so perhaps there is some way to put together some sort of group. We have various caucuses for this and that, which generally do not do much or meet very often, or do anything more than put out press releases that you are the member or chairman or whatnot of a caucus.

But I am wondering if there is not some really important and very consistent, persistent way in which we can find out what we in government can do to help the scientific community, what we are doing that hurts the scientific community, and what we can do to fix that. So that we can be meaningful and helpful participants in creating priorities and not just a collection of 535 log rollers.

I do not know if that makes any sense at all, and it has been a speech, rather than a question, I guess. But if anybody reacts to it, you know where to reach me.

The CHAIRMAN. That is pretty good on political science. I have a good answer to it. But let me yield, now, to Senator Gore.

OPENING STATEMENT BY SENATOR GORE

Senator GORE. Well, thank you very much, Mr. Chairman. Before I turn to Dr. Bloch, I would like to respond briefly to that. Former Congressman John Brademas, now the head of New York University, is chairing a group under the auspices of the Carnegie Foundation to explore exactly the topic you have just raised, how Congress can better organize itself to deal with science and technology policy.

One of their preliminary recommendations is the establishment of a group like the Energy & Environment Study Conference, which is probably the most successful extra-committee group in the Congress, and have it established for this purpose.

I agree with you, Senator Danforth, that is probably limited in what it could achieve, but I, too, am open to ideas and suggestions and I welcome your statement as Chairman of this Subcommittee on the topic. With the active encouragement of Senator Hollings, we have tried to make the Science & Technology & Space Subcommittee a stronger focal point for the discussion of these topics, and have it serve as a kind of clearinghouse for the topics you have

raised, even though we are confined in what we legislatively do to those matters we have jurisdiction over, and recognizing that the Energy Committee and the Health Committee and others have similar jurisdiction, but I am interested in working closely with you and with the Chairman on that matter.

I would like to say just a few words, Mr. Chairman, about Erich Bloch. I have one particularly vivid memory of Erich Bloch. On this particular day, he wore a huge red parka, its hood pulled down over his head, a big gray scarf wrapped round his face. I have seen him look more comfortable, and I am not really sure he enjoyed that particular location as much as you and I did, Mr. Chairman.

The CHAIRMAN. You could only tell him from his accent.

Senator GORE. That is right, coming out of the parka in bursts of a cloud, and in fairness the temperature was about 50 degrees below zero, and we were standing 9,200 feet above sea level, at the very bottom of the world, and I really do not know whether he enjoyed that trip as much as we did, to the South Pole NSF research station, but it was typical of his desire to see his agency's operations first-hand, even the most remote ones.

Nobody has ever accused Erich Bloch of not involving himself in the details. In his 6 years as Director, he has left his mark on every part of NSF, and many of these changes will leave a lasting and important legacy, such as his creation of a Directorate for Computer and Information Science and Engineering, his many efforts to improve cooperation between the Nation's research universities and industry, and his support for global change research.

The NSF he leaves after 6 years has maintained its reputation for research excellence as it has shown a new relevance to the Nation's needs. In the process, Erich Bloch has showed Congress that academic research can help with pressing problems such as economic competitiveness and the environment.

Now, if truth be told, Erich Bloch is not exactly shy in his efforts on NSF's behalf, and any member of Congress who has ever discussed appropriations with him knows that he is one of the most direct and persistent individuals in Washington.

But two traits make him special and successful: his obvious and deep concern about the future of the country, and his clear and convincing vision of what Federal programs can do to meet national needs.

In his 6 years as Director, Erich Bloch has made a difference. He will leave national science and technology policy far better than it was before he joined Government, and that is not a bad legacy. I know he is going to continue to be active and outspoken on science and technology issues. I can almost guarantee that we will continue to hear from him not only sage advice, but strong support for NSF funding, too, and I would not have it any other way.

I want to join my other colleagues here in commending you, Dr. Bloch, for your many accomplishments, and saying we expect to hear from you not only today but in the months and years ahead.

I do have a number of questions, but I am going to keep them short, and let me focus just on one off the bat, which comes out of a hearing that we had here yesterday. I noticed in an interview you had with "Science & Government Review," you talked about some of the developments in SEMATECH. SEMATECH, of course, is not

only important in its own right, it is a kind of symbol for efforts by this Nation to respond to the staggering challenge from Japan in applied research and the translation of research into new commercial products, in this case in the electronics industry.

We had a hearing yesterday which focused in part on the sale of Semi-Gas. You are familiar with the facts. The taxpayers paid 50 percent of the money to SEMATECH as it nurtured the creation of this set of new discoveries in Semi-Gas, one of the companies joined as a partner in organizing this response to the Japanese. They have become so successful at creating the purified gases necessary for advanced chip manufacturing that they are said now to be 2 years ahead of the Japanese and the leading Japanese company in that field, Nippon Sanso.

After the taxpayers and the American electronics industry, created these new discoveries, nurtured Semi-Gas and made it a viable enterprise, Nippon Sanso came in and said, we want to purchase it.

The White House had to approve the sale. SEMATECH immediately set off alarm bells at the White House and said, my God, this is unthinkable. Of course you must reject this proposal. This company has been nurtured precisely for the purpose of responding to the Japanese. Moreover, we have secrets that are locked in this company's files and in the work they are doing, and it is unthinkable to turn that over to the people that we have organized this company to compete with.

President Bush said no, whatever the Japanese want is okay with me, and he approved the sale. SEMATECH said well, at least protect our secrets. It is going to cost up to $100 million. It will cost us 6 months time to try to get some replacement for Semi-Gas, but at least protect our secrets.

The Treasury Department sent out a press release that it had negotiated an agreement with Nippon Sanso to protect the secrets. SEMATECH testified here yesterday they have never been consulted, and to this day have never been even told what that agreement is. They read about it in "The Wall Street Journal."

The employees and managers of Semi-Gas attempted to organize a buy-out to keep it in American hands. They bid $189 million, compared to $23 million from Nippon Sanso. They needed another few days to try to get an extra $5 million. The White House said no. Nippon Sanso is ready to buy it now.

If we are going to have an intelligent science and technology policy that is relevant to the competitive challenges we face in the world, should we not support a venture like SEMATECH and summon the courage to say no to the Japanese when they attempt to rip out vital components of SEMATECH and use them to further win the battle? Nippon Sanso will now have up to 75 percent of the global market in this particular key product. What is your personal opinion of the Semi-Gas sale? You are going to be leaving at the end of this month. I know you are probably in——

The CHAIRMAN. Do you want him to leave early?

Senator GORE. You are probably in an internal transition stage now, Mr. Bloch. Senator Hollings has thoughtfully organized this hearing, and it is indeed very appropriate. Make the most of it, Mr. Bloch.

Mr. BLOCH. Thank you, Senator. I do not need your encouragement in that regard. But let me comment on it. Again, I am not familiar with the details on Semi-Gas, but in a generic way I want to make a comment.

First of all, SEMATECH was organized based on the insight that we needed to keep the semiconductor industry as part of the U.S. industrial environment, because it was much too important an industry sector to let go completely, so that we do not have any controls over it. SEMATECH was organized as a joint kind of a venture with the government participating in it, in funding half of the expenditures, the other half coming out of the companies. It has been in existence for two years and has done some very good work.

The jury is not in yet on what it will do for that particular industry, but that is to be expected, because it takes 5 to 10 years before you see the effect in real terms.

As part of SEMATECH, looking at all the aspects of technologies that are required in that particular area, Semi-Gas was obviously being looked at as a very important kind of an endeavor, and that is why it was funded. I would want to say that we need to keep these technologies in the country.

Now what the Treasury can point out by having it in Japanese hands, it is still in this country. It is not somewhere else. I will take a dim view of that. I think it is very important in these fast-moving fields to keep the development and the research and everything else here and not just the production capabilities. And we have seen in the past that when a company gets into foreign hands, over time, the basic decisions are being made elsewhere, and in many cases the basic research is being done elsewhere.

So I take a dim view of that also, not knowing, however, the situation with regard to Semi-Gas. But, in general, I would want to say that we have to keep these downstream industries intact also.

I give you another one, which is semiconductor materials. We do not have an American semiconductor materials company any longer. And that is a serious situation.

Senator GORE. Well, I certainly agree with you, and I appreciate you speaking candidly about that matter. I personally think that President Bush is frightened of the Japanese. I think his approach to technology policy with the Japanese is identical to his approach to human rights policy with the Chinese. Over the last 19 years we have seen a kind of leveraged buyout of the U.S. economy, and he is now depending upon the Japanese to finance the interest charges. As a result, he is very timid about challenging the Japanese, even when they come in and rip the guts out of an important effort to compete with the Japanese.

It is a kind of an electronic Teapot Dome. And he is acquiescing in it. And I think it is unfortunate.

Mr. BLOCH. Can I make a comment on that?

Senator GORE: Surely.

Mr. BLOCH. I must say that President Bush has talked about this area in a general kind of a way.

Senator GORE. He is good at talking in a general kind of way.

Mr. BLOCH. On the support of generic technologies by his administration, and the interest in generic technologies by his administration. There are a number of studies going on in that regard as

you are well aware of it. Some of them instigated by congressional requests, some of them not. So I would think that the administration is looking at this particular area, and I hope that something will come out of it.

SEMATECH was I think a point of departure. It exists. It is in place. And I think it can serve us as a guidepost for other areas.

Senator GORE. Well, in conclusion, Dr. Bloch, I again want to commend you for your service. And I followed your statement very carefully and found very little with which I disagreed. I have greatly enjoyed the opportunity to work with you. I joined this committee at just about the time you came on as head of the NSF. And I have benefitted from the chance to communicate with you over these last six years. And I certainly wish you well.

I hope we will be seeing an awful lot more of you.

Mr. BLOCH. Thank you.

By the way, I should mention that I enjoyed myself on that Antarctica trip. In fact, so much that some of my colleagues suggested I should stay there.

The CHAIRMAN. Senator Rockefeller.

Senator ROCKEFELLER. Thank you, Mr. Chairman.

I really enjoyed Senator Danforth's reflections, in the sense of the monumental frustration as we sit here arguing over senseless things, as you say, doing very little, while we just steadily erode. And then how do we overcome that?

I want to follow up on Senator Gore's comments about Japan. "Dr." Bloch, which you are not, which I think is one of the final tributes to you. Pat Windham is brilliant and covers the science and technology for this committee, and you finally even tricked him. Because you are not Dr. Bloch, you are Mr. Bloch. And for six years we have all been calling you Dr. Bloch, and I think simply that represents our respect for you.

If the difference is not cultural—we talk about an economic challenge from the Japanese, and of course that is the fact. The Japanese, I think, and you correct me if I am wrong, they make decisions strategically, and they make decisions because those decisions emanate from a culture, not from an economic pattern. The economic pattern derives from the culture. And the culture is that they are homogeneous, that they are an island, they do not have natural resources, and all of those things. The culture derives from their instant response when Commodore Perry went there in 1853 with these big ships and said you have got to open up your ports.

The Japanese, knowing they did not have the technology, and wanting the technology, started sending people all over the world. With Perry there, they delivered to the United States their first market-opening package, which was you can come into Shimoda, Commodore Perry, and you can come into Hakodate. Now one of these ports is way in the North of Japan, which one would not have gone to back then, and the other, Shimoda, was 150 miles from Tokyo.

In other words, their first kind of response was cultural. Because they did not want to lose their identity. They make their decisions with the instinctive feeling that corporations and business and government work together. It was not a nasty decision, it was just sort of an automatic decision on their part. They saw their deficiencies

and proceeded to correct them. And did so, indeed, so rapidly that they clobbered the Soviets, or the Russians, in the Russo-Japanese War in 1904 and 1905, because of their superior technology. They had made an enormous leap in 50 years.

So they see the business of getting ahead as part of their cultural expression, what they are as a people. That is, deficient in resources, small in space, and therefore, we have got to make up for it by all working together.

Americans, on the other hand, see ourselves as somehow so impregnable because of the vastness of our resources, the vastness of our land, that we take the John Wayne approach. We love Steve Jobs and each person left to his own, and the sum of the total equals a brilliant American future. And it obviously is not working.

Reflecting on what Senator Gore said, about vacating the field to the Japanese. This has not just been government. I mean this is a specific American corporate policy. Without any coordination since the 1950's about 30,000 separate agreements have been worked out between the Japanese and individual companies, small, medium, and large, in this country. For the price of $17 billion, the Japanese have virtually purchased our technology.

It was not a government decision. It was not President Bush's decision. It is the perfect American response. You know we have this technology. You are offering us a price. Yes, we will take the money and we will give you our technology. And it is repeated and repeated and repeated and repeated, and we begin to erode. And there is no real great secret about that.

What you do not do in the United States is have the American Government work with American industry, because that implies that the Lone Ranger is not riding. And we do not want to think that about ourselves.

Now my question is, we savage ourselves because of our cultural belief in ourselves. We do not understand the world. We ought to, but we do not. In this science and government article that Senator Gore is referring to, you were asked a question about reciprocity in the U.S. and Japan Science and Technology Agreement, where our students are going over there.

I mean the Japanese opened up their universities in some measure, and I think we predicted a year ago here that the U.S. was not going to respond to that because, one, we did not have that many scientists and engineers; secondly, even if we did, they were not going to be willing to study Japanese. And you do not really learn a lot in a Japanese laboratory without so doing. So, again, it is cultural.

Do you see any movement to alleviate this enormous deficiency in scientists and engineers? I remember you and I once had a colloquy in which I think we both agreed that if you were going to be an engineer or a scientist in this country that you had to decide by around the age of 11 or 12. There have got to be a series of role models out there.

That means the salaries that engineers and scientists make in corporations, how high do they rise. Is it lawyers and accountants or is it scientists and engineers that run our companies? And we discussed the very clear pattern of that. The answer in Japan is

the scientists and engineers. In America it is accountants and lawyers and financial experts, et cetera.

So, philosophically, do you see any cultural change? Are we in fact afraid in a way which is causing the beginnings of certain changes? And I will just say that there do seem to me more people who are going into teaching than was the case 2 or 3 years ago. And there is no real clear reason for that, but it seems to be happening.

There does seem to be an instinct, certainly not government mandated, for American students to be doing more languages, including a lot of Japanese. There is a tremendous number of young people studying Japanese. And the Japanese will undoubtedly, and in fact is employing those people to work over in Japan on their behalf.

Do you see us awakening if this is a cultural problem? My question was not good, but you know what I am trying to ask, and I am interested in your response.

Mr. BLOCH. Senator, you are asking a very good question, and I might say right at the outset that my answer is not very authoritative on it, because I am kind of an optimist, and so I see probably things a little bit more rosy than they actually are. But I see a movement, yes.

Again, a couple of things we discussed already this morning, SEMATECH is one example, would not have happened 10 years ago—very clear. Companies would not have stood still for that. It did happen, and that is a good example.

I do not think 10 years ago you could have done some of the things that we did in the National Science Foundation, pushing industry and academia closer together through the Engineering Research Centers, or through the Presidential Young Investigator program, or many of the other programs, and that is happening and has happened.

By the way, the participation of industry is kind of gratifying, but also the acceptance by universities to that concept is kind of gratifying, because the problem was on both sides, with a big gap between academia and industry. So that is an example.

I think if you scan—and I know we all do—the press day in and day out and weekly and monthly, you see more of a focus on this issue that I talked about the generic technology and how we are losing that base in the country. You are seeing that expressed, and I think that is a change, and so I see some movement.

Are we there where we should be? No, I do not think so, and also one should not read too much into these changes, because we start off on a track and then we get tired of it, and then we do something else again and it is forgotten and forgiven, and persistence is kind of important. So I see some changes.'

Senator ROCKEFELLER. Mr. Chairman, I know I am way over my time. I would just conclude with an observation: There has been all of the drama, starting with machine tools and then the Japanese just went after one technology after another, and of course the Europeans have done the same but in different ways. Most of this has taken place in the last 15 years.

So you could say that things have moved very, very quickly. Now we are reading all of the books about our deficiencies, the Young

Commission was but the first warning cry. You would have to say that the responses that Senator Danforth, Senator Gore and I and Senator Hollings obviously are concerned about bringing about are going to have to happen fairly quickly.

We do not really have 30 or 40 years to worry about this. We have to move fairly quickly.

I am worried. I do wish there could be a way that we could cooperate, inter-committee or intra-committee, whatever the right word is, to work on these things.

Erich Bloch, I think, has been a great benefit to the Nation. Like Senator Gore, you have been the head of that Foundation since you have been here. You have been very aggressive, always wanting more money for the Foundation and always very, very firm about it. I am personally grateful to you for coming to West Virginia, which no other Director of the National Science Foundation has ever done, to look at some of our science and technology opportunities and problems, and you have been hands-on. You have been aggressive. You have been a wonderful, wonderful benefit, a wonderful public servant, and I certainly am going to miss you, Mr. Bloch.

Mr. BLOCH. Thank you very much.

The CHAIRMAN. Mr. Bloch, in your answer to the question about not just priorities but needs, you started right at the base. You you said that at the elementary and even kindergarten level what you have are the seed corn to be nurtured and grown, We must go right on up the line, not picking out a particular SEMATECH.

Now, there it is. Let me sort of characterize and then you correct the characterization.

I would go on to the floor of the Senate and say, wait a minute, we have just heard from the most eminent scientist and engineer in the land, and he told us, let us get going on the basics here in this country, and perhaps rather than running down the road of an $8 billion supercollider, or running down the road of a $500 billion dollar go-tomorrow's program, why not go down a $500 billion dollar road of womens', infants' and childrens' feedings, and Head Start, and Title I for the disadvantaged.

Then into the colleges and universities, where we are going to be shy of 500,000 bachelor degrees in science and engineering and 150,000 doctorates in these fields by the turn of the century. Let us start building so that we can better compete, rather than pouring all our monies into a single collider or Mars approach.

Incidentally, since we are talking money and there is a shortage, I know that for every $1 I have spent on WIC—Womens, Infants and Childrens feeding, I save $3. For every $1 I spend on Head Start, I save $4.50. For every $1 I spend on Title I for the disadvantaged, I save $6. For every $1 I put in biomedicine out here at NIH I get $11.50 return.

So while I am spending now, by the year 2000 I am saving a heck of a lot of money. It is cheaper to feed a child than it is to jail a man. I have that budget. I am building prisons like gang busters, every State, all over everywhere—prisons more than I am classrooms and science labs.

So I would say, listen to the best of engineers and scientists, Dr. Bloch. Let us go down the road here, and let us start building up

these basics, rather than just the computer chip, or just a little, singular program around here because that is all we can think of.

What would be your comment? Am I going at it the wrong way?

Mr. BLOCH. No, I do not think you are going at it the wrong way. I think I would broaden the net a little bit. I mentioned before that these big projects are kind of important, also, but that one has to keep one's priorities straight, especially in the constrained environment.

Another area that I think one needs to look at is the total R&D investment of the Nation, or of the Federal Government, which is over $70 billion this year, something like $72 billion, and if within the budget, if the allocation is correct. That is what I was really addressing. I will say no, it is not correct.

It is not correct because too much is going to development-type work and not enough to basic research. Too much is going to Defense and not enough to the civilian R&D budget, and I think these internal R&D budget changes are very important to make, and so I would start there.

It is a more limited kind of an envelope, but it is a very important one, and it is one that has a lot of money in it by itself.

The CHAIRMAN. What would you say to moving DARPA from Defense to the Bureau of Standards, move from DARPA over in Defense to the Bureau of Standards, which is now the National Institute of Technology over in Commerce, where we have that talent. We could do this instead of getting financial support for it and they just go over to DARPA and fire Greg Fields because he got competitive, which goes along with the electronics case that Senator Gore is citing.

Do you know of any other way to get R&D out of Defense and put it into the civilian side? If you were a Senator, what bill would you introduce?

Mr. BLOCH. Well, I am not a Senator.

The CHAIRMAN. But you can act like one. I have been with you.

Mr. BLOCH. I am not faced with that problem. But I would say, by the way, DARPA is doing probably more basic research than anybody else in the Defense Department. So let us not take it out on DARPA.

But I would say that the whole defense part of the R&D budget needs to be really, really looked at, and seeing that we get back, and we are, by the way. We are going backwards into a better distribution between civilian and defense. But I do not think we are doing it quick enough. Or we should be back to a 50/50 kind of split, the way we were 15 or 20 years ago.

The CHAIRMAN. Well, I cannot thank you enough. We, unfortunately, are into the short rows here, today, tomorrow, and perhaps Saturday night, trying to get out of town. We will leave the record open.

Are there any other questions of our colleagues?

[No response.]

The CHAIRMAN. The country, and this committee particularly, are indebted to you, Mr. Bloch. We appreciate it very, very much. We wish you well.

Mr. BLOCH. I thank you.

The CHAIRMAN. The committee will be in recess.

[Whereupon, at 11:30 a.m., the hearing was adjourned.]

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